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DRAWINGS ATTACHED

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(54) BOOKBINDING WITH WELDED PAGES

(71) We, MORTIMER SAMUEL SENDOR and BERNARD THEODORE SENDOR, of 80-30 221st Street, Queens Village, Long Island, New York, United States of America, and 608 Blair Drive, Westbury, Long Island, New York, United States of America, both citizens of the United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is concerned with the binding together of leaves of paper to form a book.

There are many conventional ways by which pages and signatures of a book are connected together. These include the use of staples, either through the fold of a signature as in pamphlets and magazines; or through the sides of the pages near the rearward edges in other cases, particularly thicker books. Sewing is also used, but the most common methods use adhesive, either alone or in combination with stapling or sewing. Mechanical and looseleaf binding can also be used. All of these methods involve substantial amounts of labour and cost.

An object of the present invention is to provide a method of binding books without the use of adhesive, staples, sewing, mechanical or looseleaf binders for holding the pages of the book together. Instead of using the expedients of the prior art, this invention uses leaves made from sheets of paper that can be welded together, the composition of the sheet being uniform throughout its entire area since when the sheet is made, no one knows what parts of its area will eventually be the edge portions of a book made from the sheet. Applications of concentrated heat applied to clamped-together leaves cause them to weld to one another to produce connections that compare favourably with the conventional binding mentioned above.

[*Price 25p*]

This invention provides methods for making books by welding together special sheets and without the use of adhesives, staples or stitching. The sheets are made of paper and the term "paper" is used herein with the meaning set forth in Webster's Unabridged Dictionary (2nd Ed.) which defines "paper" as: "a substance made in the form of thin sheets or leaves from rags, straw, bark, wood or other fibrous materials, for various uses".

This invention uses a kind of paper incorporating thermoplastic resin with the fibres which can be welded to similar sheets. The term "weld" is used herein to designate a connecting of sheets by sealing them together as the result of the application of heat to the surfaces of the material of the sheet and without applying adhesives or other intervening material to the sheets for binding.

The term "book" is used herein to designate magazines, pamphlets, letters and folders, regardless of the number of pages, and down to two or more leaves.

The connections are not the same as "welds" made with metal, but they do have characteristics in common with metal welding. For example: the sheet welds can be made at lower temperature if more pressure is used, and can be made with only enough pressure to hold the leaves in firmly assembled relation if sufficient heat and subsequent cooling is used. There are also distinct differences from metal welding. The stack of paper leaves is not a good conductor of heat, though the conduction is improved by pressure. The sheets cannot be melted and puddled, as with metal. The "weld temperature" of the sheets is that temperature at which the confronting faces of the different areas of the sheets react with one another so that they are bonded to-

gether when they cool. The specific temperature depends upon the material used for the fibres and fillers of the sheet, the nature of its resin content, and upon the moisture in the sheet.

In analyzing the reaction which occurs, it appears that heat is necessary, but the term "heat" is used in a broad sense to include high intensive dielectric fields applied for short duration. For thin books, where only a few leaves are involved, hot clamping jaws can be used because the heat can flow relatively quickly through the thin group of leaves. For a thick book and low heat-conductivity sheets, radio frequency electronic heating is advantageous because it generates the heat within the sheet itself and it is not necessary to depend on conduction and temperature gradients. The heat is applied to the edge portions while at the same time excluding the remaining portions of confronting surfaces of the leaves from welding temperature.

It is desirable to have the leaves of the book secured together along only narrow areas of their bound margins. Clamping pressure for the welding may be over such a narrow area as to be insufficient to hold the leaves in their desired assembled relation to one another. For this reason, the methods of this invention include embodiments where the same stack is clamped by different clamping forces, and the one for merely holding the leaves of the stack in assembled relation while being welded, may be of different clamping pressure than the one that co-operates with the welding temperature to make the weld.

Other parts of the invention are embodied in the preferred forms thereof which will now be described with reference to the accompanying drawings in which

Figure 1 is a view of an unfolded sheet for use with this invention;

Figure 2 shows the sheet of Figure 1 folded once in a lengthwise direction and once in a crosswise direction to produce a signature having eight pages (four leaves);

Figure 3 is a view similar to Figure 1 but showing a sheet which is to be folded once along a crosswise fold and twice along endwise folds to produce a signature of sixteen pages (eight leaves);

Figure 4 shows an elongated sheet folding along parallel endwise folds in accordion fashion to make a multi-leaf signature;

Figure 5 is an end view of the sheet of Figure 4 with the sheet partially folded to illustrate the principle of the accordion folding;

Figure 6 is a diagrammatic sectional view showing the way in which a single signature or inserted signatures can be welded along the fold line between heated clamped jaws;

Figure 7 is a diagrammatic sectional view showing the way in which the marginal portions of thicker books are welded together;

Figure 8 is a diagrammatic sectional view illustrating the welding of the marginal portions of an accordion-folded signature and with stray field electrode high frequency heating;

Figure 9 is a diagrammatic sectional view showing still another modification of apparatus for welding the marginal portions of a signature together with intermittent regions of welding along the weld line;

Figure 10 is a sectional view taken on the line 10-10 of Figure 9;

Figure 11 is a sectional view taken on the line 11-11 of Figure 8;

Figure 12 is a diagrammatic view showing a modification of the heating means of Figure 6 designed for continuous operations, as with a conveyor; and

Figure 13 is a diagrammatic view showing another modification of the invention.

Referring to the drawings, Figure 1 shows a sheet 9 which is to be folded along a crosswise line 10 and along an endwise line 12.

Figure 12 shows the sheet 9 after folding. The first fold is made along the crosswise line 10 and the sheet after this first folding is folded along the endwise line 12. Thus each leaf of the signature so formed is connected with another leaf along the center fold line 12, and the leaves are also connected together along the line 10. When the signature is trimmed, the portions which are connected along the lines 10 are cut off, in accordance with conventional practice.

Figure 3 shows a sheet 9' which is folded first along an endwise fold line 14, and then along a crosswise fold line 16. The sheet is then folded along endwise lines 18 which are superimposed over one another by the previous folding and this produces a signature having eight leaves and sixteen pages, with each leaf joined to one another along a center fold which is made up of the folds along the lines 14 and 18, all of which are adjacent to one another in the final signature.

Figures 4 and 5 show another common way of making signatures. A sheet 9a is folded along fold lines 20 with the fold at each successive line 20 in an opposite direction so as to produce an accordion fold, as shown in Figure 5. When the folds are completed and the successive lengths brought into contact with one another, the signature has half of the sheets joined to one another at one side and the other half joined to one another at the other side, as shown in Figure 8. These are only an example of types of folds or combinations of folds that can be made either in flat sheets on folding machines or rolls of sheet material printed

and folded on printing equipment.

The folding procedure described above, and over-and-over folds, and many other ways in which sheets can be folded to make a thin book or to make a signature for a thicker book are well understood in the art and the examples explained here are to illustrate the important fact that when the sheet is manufactured, the manufacturer does not know what part of the area of a sheet will constitute a marginal portion of a sheet which is to be bound for the finished book. In making sheets where the leaves are to be welded together, therefore, it is necessary to make the sheets with its entire surface area of a uniform composition so that no matter what part of the area of the original sheet becomes the edge portions of an assembled signature, the edge portions are of a composition to be welded.

One way to make paper weldable is to have the paper contain sufficient quantity of thermoplastic resin to cover most of the surface fibre of the paper. A paper with a layer of polyethylene resin extrusion coated on each surface at the rate of six pounds per 3,000 ft.^{2} is one example of such a paper, but the paper can be uniformly impregnated through its full thickness.

If the book or signature contains only a few leaves, such as the leaves 24 of Figure 6, and the folding is like that described for Figures 1-3, then the leaves can be welded together along a center fold line 26 between heated clamping jaws 28 and 30 applied to the inside and outside of the back folds of the signature respectively.

In the construction shown, the clamping jay 28 is tapered to a rounded upper edge 32 which can be a dull chisel point. It should not be sharp because of the danger of cutting the paper; but a more important reason is that the width of the clamping contact of the jaw 28 determines the width of the weld and the strength of the weld is increased as the width increases. The signature consisting of the pages 24 can be draped over the lower clamping jaw 28, as shown in Figure 6, and the upper clamping jaw 30 is then brought into contact with the outside of the center fold to press the folded leaves together between the heated jaws 28 and 30.

The temperature of the clamping jaws 28 and 30 must be higher than the welding temperature of the paper sheet but not high enough to scorch or otherwise deteriorate the paper along the fold. The welding temperature, as previously explained, must be higher than the bonding temperature in corporated resin and depends upon the composition of the paper. The heat must be maintained long enough to penetrate by conduction through the paper which is in contact with the jaws and to heat the inner sheets of paper to welding temperature. This is done more quickly by using higher pressure, but the pressure must be kept to a value which will not be cut or tear the paper and this, in turn, depends upon the sharpness of the end of the lower clamping jaw 28. The upper clamping jaw 30 has a recessed face curved about an axis and with a radius of curvature preferably slightly greater than the radius of curvature end of the lower clamping jaw 28.

The lower clamping jaw 28 may be a part of a conveyor which brings successive signatures to a welding station, as will be described in connection with Figure 12, and the upper clamping jaw 30 can be brought into contact with the successive signatures as they reach the welding station. The clamping jaws 28 and 30 can be heated by any conventional heating means with sufficient capacity to maintain their temperature as they operate on successive signatures and with the necessary controls to prevent the temperature from reaching excessive values.

With the welding method illustrated in Figure 6, the weld can be confined to the fold of the sheet and the center of the book can be opened flat thus excluding remaining portions from welding temperature. However, the time for welding is longer as the number of pages used in the method of Figure 6 is increased. This is because of the relatively poor heat conductivity of paper sheet; and the number of pages which can be welded by the thermal sealing illustrated in Figure 6 is limited to comparatively a few leaves if the operation must be accomplished quickly.

The use of a hot clamping jaw at 350°F has been used to weld paper successively without any deterioration of the paper but the depth of penetration of the heat is inversely proportional to the thickness of the paper between the clamping jaws and greater thickness cannot be compensated for by raising the temperature because of discoloration of the paper. Clamping-jaw temperatures of 400°F have discolored the paper in actual practice. These temperatures are given merely by way of illustration since the results depend upon the total composition of the paper sheet.

Where greater thicknesses of sheet are involved, i.e., where the number of leaves is substantial, sealing without relying upon conduction of heat through the sheet must be used, for example, radio-frequency energy, as will be described in connection with other figures. Radio frequency may be less desirable where only a few sheets are involved. For signatures as thick as 16 and 32 pages, better results are obtained with heat sealing by very high radio frequency energy, preferably about 27 M.h. (Mega Hertz).

Radio-frequency energy has been used advantageously for welding the paper with a frequency of approximately 27 M.h. Higher frequency up to about 45 M.h. can be used to obtain the same results at reduced voltage. A 16-leaf signature can be sealed in one half second with a power output of 1.3 k.w. and with the frequency approximately 27 M.h. No cooling time was required.

With a 32-page signature, the power output was about 1.8 kw and other factors remained the same. These results are given merely by way of illustration, and the paper used to obtain these results was obtained from P. H. Glatfelter, Spring Grove, Penna.; the Glatfelter identification for the paper being "Self Binding Paper", a Glatfelter trademark.

Figure 7 shows two signatures 40 and 42. If these signatures are thin, they can be previously welded along their folds in accordance with the method discussed in Figure 6. This can be done to hold the individual signatures in assembled relation, but it is not necessary when a signature is to be welded to another signature because the same welding which joins signatures together also joins the leaves of the individual signatures to one another.

Figure 7 has clamping jaws 44 and 46 which hold the signatures in assembled relation with one another. These clamping jaws 44 and 46 may cover the entire areas of the signatures 40 and 42 except for the edge portions which are to be welded. Other clamping jaws 48 and 50 contact with the edge regions of the signatures 40 and 42 and press these edge regions together with substantial pressure.

The clamping jaws 48 and 50 may be heated to supply the necessary welding heat in Figure 7 Because of the low heat conductivity of most kinds of paper, it is more advantageous to heat paper by using a high frequency electromagnetic field from a stray field electrode assembly 51, as will be more fully explained in connection with Figures 8 and 11. The high frequency dielectric field heats the paper between the jaws 48 and 50 and the heat is generated in the paper itself so that it is not necessary to rely on temperature gradients or conduction to reach the inner leaves. The intensity of the field and its duration are sufficient to bring the paper to a welding temperature between the clamping jaws 48 and 50.

The width of the weld is controlled by having the clamping faces of the jaws 48 and 50 relatively narrow. Because of this narrow width of the jaws 48 and 50, and the fact that they are close to one edge of the stack of leaves, it is advisable not to rely upon these jaws as the only means for holding the signatures in the desired assembled relation. The clamping jaws 44 and 46 are representative of other means for holding the signatures in the desired assembled relation during the welding operation.

The stack, consisting of the signatures 40 and 42 adjacent to the edge portions which are between the jaws 48 and 50, is clamped at a lesser pressure insufficient to cause welding of the leaves at the temperature generated therein by the high frequency field.

Figure 8 shows clamping jaws 54 and 56 clamping leaves 60 which are formed by the accordion folding of a sheet in the manner described for Figures 4 and 5. These clamping jaws 54 and 56 hold the leaves 60 together under sufficient pressure to maintain them in the desired assembled relation and with their edge portions 62 extending beyond the clamping jaws 54 and 56.

A stray field electrode assembly 51 extends across the edge portions 62. This assembly includes a group of bars 63 alternating with bars 64 of another group. Adjacent bars are of opposite polarity and in the construction illustrated in Figures 8 and 11, the bars 63 and 64 are somewhat longer than the thickness of the group of leaves 60; and each row of bars is longer than the extent of the leaves from the tops to the bottoms of the leaves so that the same apparatus can be used for welding the pages of books of different heights and of different thickness. This apparatus is representative of means for welding the pages by high-frequency electronic heating. Clamps 54 and 56 are preferably ceramic material, not heated substantially by the dielectric field. It will be understood that this apparatus can be used for separate leaves, signatures, or any combinations, no matter how assembled, in addition to its use with the accordion folding illustrated.

Figure 9 shows leaves 70 which are separate from one another, i.e., not connected by any fold lines. These leaves 70 are held in assembled relation by the clamping jaws 74 and 76 which cover sufficient areas of the sheets to hold them in the desired assembled relation; and edge regions 72 are clamped between other clamping jaws 78 and 80. These clamping jaws 78 and 80 have projections 82 at opposing locations for clamping small spaced areas of the paper between them under substantial localized pressure. These jaws 78 and 80 may be vibrated toward and away from one another at supersonic frequency, with heating supplied by electric current through the wires leading to the clamping jaws 78 and 80.

Figure 10 shows the electrode clamping

jaw 80. The upper jaw 78 may be of similar construction but opposite orientation. The face of the jaw 80, which contacts with the sheet, has projections 82 which contact with the sheet at spaced locations to obtain intermittent regions of high pressure. The apparatus in Figures 9 and 10 produces welds which are intermittent or discontinuous along the line of the weld, whereas with the apparatus shown in the other figures, the weld is preferably continuous.

Figure 12 shows a modified form of the thermal sealing method of Figure 6. The leaves 24 are dropped over a lower support 28a which takes the place of the lower clamping jaws 28 of Figure 6. A pressure roller 30a takes the place of the upper clamping jaw 30 of Figure 6. Both the support 28a and the pressure roller 30a are heated; and the support 28a is preferably part of a conveyor that carries successive pamphlets or books, containing leaves 24, past the roller 30a.

Instead of the heated roller 30a, a hot contact bar can be located along the path of the leaves 24 to supply the heat and pressure for welding the leaves together at their folds. A shoulder 86 on the support 28a prevents the leaves from sliding off the support and provides the thrust for advancing the leaves. If desired, the roller 30a or contact bar can move lengthwise of the book or leaves 24.

Figure 13 shows another modification of the invention for binding multiple sheets or signatures of resin-containing paper 88 accomplished by the application of infra-red energy 89 from a source 90 to the edges of paper firmly gripped by clamping jaws 92. The infra-red heat source 90 may be replaced by a heated element that is applied to the edges of multiple leaves. The binding of single leaves as well as multiple signatures is possible by this method.

The preferred embodiments of the invention have been illustrated and described, but changes and modifications can be made and some features can be used in different combinations without departing from the invention as defined in the claims.

WHAT WE CLAIM IS:—

1. The method of binding together paper leaves of a book which leaves are made from a sheet of paper larger than the leaves of the book, the sheets being cut along lines that comprise the eventual edges of the leaves, the sheet being of printable and weldable paper which includes a thermoplastic resin system incorporated with the fibres of the paper and providing a composition across the entire surface of the sheet, from which the leaves are made, weldable at any region of the surface thereof, whereby edges of the leaves made from the sheet are weldable regardless of the size of the leaves formed by cutting or folding the sheet prior to binding of the leaves together, holding the leaves in a desired assembled relation in contact with each other, and subjecting the confronting surfaces of the leaves along their edge portions at one side of the assembly to the welding temperature and pressure of the paper while in said assembled relation, and at the same time excluding the remaining portion of the confronting surface of the leaves from said welding temperature.

2. The method as claimed in claim 1 in which the paper includes a resin system that bonds the sheets together at a temperature substantially higher than the ambient atmospheric temperatures to which books are subjected in normal use, but less than the heat-discoloration temperature of the paper, and in which the edge portions of the leaves are firmly clamped so as to obtain intimate surface contact of the leaves over at least the portions of their areas that are to be welded, and while so clamped, the clamped portions are brought to a temperature in excess of the bonding temperature of the resin system.

3. The method as claimed in either of claims 1 and 2 in which the book is made from large paper sheets without the use of adhesive and in which a sheet having surfaces of uniform composition throughout its surface entire area is folded both endwise and crosswise to make a signature having a plurality of leaves with folds along different margins of the folded sheet but with one side along which each of the leaves joins another leaf at back folds of the sheet, pressure being applied to all of the back folds from the inside thereof along said one side of the signature, and complementary pressure being applied to the outside of the signature along said back folds to weld the leaves together at their back folds along said one side.

4. The method as claimed in claim 3 in which a plurality of signatures are clamped together to form a multi-signature book, and the successive signatures are welded to one another adjacent to their welded folds.

5. The method as claimed in either of claims 1 and 2 in which the book is made from large sheets of paper without the use of adhesive and in which a paper sheet of uniform composition throughout its surface is folded back and forth with an accordion fold to make a signature, pressure being applied to the signature from both the front and rear thereof at least along the margins at one side of the signature where there are superimposed folds, the sheets being welded along the margins at which the pressure is applied, and trimming the folded sheet to remove the folded edges on

the side of the signature opposite the welded folds.

6. The method as claimed in any of the pereceding claims in which the portions of the leaves to be welded are clamped between heated clamping jaws, and the pressure of the clamping jaws is maintained until the innermost sheets reach a welding temperature.

7. The method as claimed in any of the preceding claims in which the edge portions that are to be welded are subjected to a high-frequency electronic field that generates heat in all of a stack of the leaves simultaneously whereby the leaves are brought to welding temperature quickly without requiring heat conduction through the paper of the other superimposed leaves.

8. The method as claimed in claim 7 in which the edge portions to be welded are clamped in a stack under pressure sufficient to cause welding of the leaves at the temperature generated by the high-frequency electronic field, and the stack adjacent to the edge portions is clamped at a lesser pressure insufficient to cause welding of the leaves at the temperature generated in the leaves by the high-frequency field.

9. The method as claimed in any of claims 1 to 7 in which the superimposed leaves are clamped together over a substantial area of the leaves, and other higher and localized pressure is applied to edge portions of the leaves that are to be welded to one another.

10. The method as claimed in any of the preceding claims in which the welding is continuous throughout the full length of the binding edge of each of the superimposed leaves.

11. The method as claimed in any of claims 1 to 11 in which the welding is intermittent along the length thereof.

12. The method as claimed in claim 13 in which the superimposed leaves are subjected to spaced and localized regions of pressure along the line of welding, and the paper is welded only at the localized region of the pressure.

13. The method as claimed in any of the preceding claims in which the welding heat is generated in the edge portions of the leaves by stray field radio-frequency electronic heating of a frequency between about 27 and 45 M.h.

14. A method of binding together paper leaves of a book substantially as described with reference to any of Figures 6 to 12 of the accompanying drawings.

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1 SHEET

COMPLETE SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale.

FIG. 1.
PRIOR ART

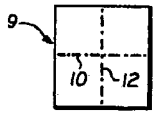

FIG. 2.
PRIOR ART

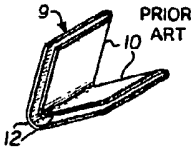

FIG. 3.
PRIOR ART

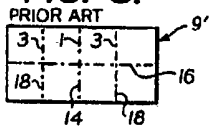

FIG. 4.

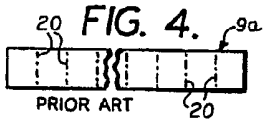

FIG. 5.

FIG. 6.

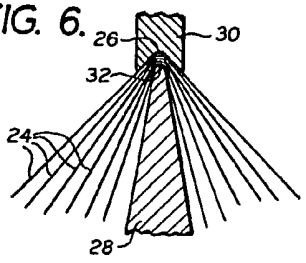

FIG. 7.

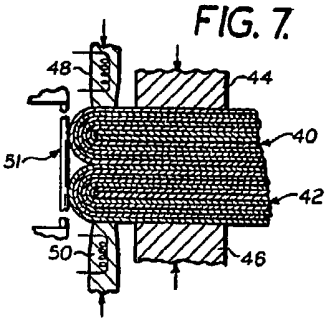

FIG. 8.

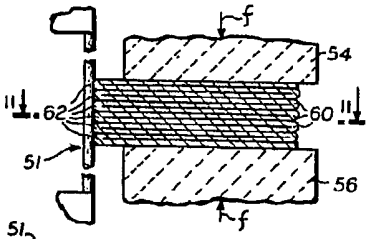

FIG. 9.

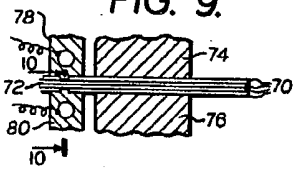

FIG. 10.

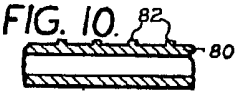

FIG. 11.

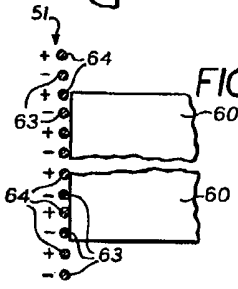

FIG. 12.

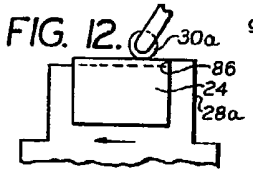

FIG. 13.